King's Research Portal

DOI:
10.1016/j.forsciint.2018.09.005

Document Version
Peer reviewed version

Citation for published version (APA):
Jayaraman, J., & Roberts, G. J. (2018). Comparison of dental maturation in Hong Kong Chinese and United Kingdom Caucasians populations. *Forensic Science International*. https://doi.org/10.1016/j.forsciint.2018.09.005

Accepted Manuscript

Title: Comparison of dental maturation in Hong Kong Chinese and United Kingdom Caucasians populations

Authors: J. Jayaraman, G.J. Roberts

PII: S0379-0738(18)30726-6
DOI: https://doi.org/10.1016/j.forsciint.2018.09.005
Reference: FSI 9474

To appear in: *FSI*

Received date: 17-5-2018
Accepted date: 5-9-2018

Comparison of dental maturation in Hong Kong Chinese and United Kingdom Caucasians populations

Jayaraman J[1]*, Roberts GJ[2].

[1]Dr. Jayakumar Jayaraman, BDS, MDS, DipFHID, MPaed Dent RCS, FDSRCS, PhD.
Children's Dentistry & Orthodontics,
School of Dentistry, International Medical University,
Kuala Lumpur 57000, Malaysia
e-mail: jayakumar83@hotmail.com
Phone: +601112108642
**Corresponding Author*

[2]Prof. Graham Roberts, MDS, MPhil, BDS, FDSRCS, ILTM, DipFHID, PhD.
Department of Orthodontics,
King's College London Dental Institute,
22/F Guys Tower, London SE1 9RT,
United Kingdom
e-mail: graham.roberts101@outlook.com

Highlights

- First ever study to provide insight on dental development through direct comparison of tooth development stages from a large sample of Caucasians and Chinese populations.
- Outcomes of this study has significance in both clinical and forensic applications, particularly in dental age estimation.

Abstract

Understanding dental maturation in ethnically distinct populations is important in forensic age estimations and the presence of population differences in dental maturation was highly debated. No such comparison had been performed between two major populations; Caucasian and Chinese. This study aims to analyse and compare the maturation of permanent teeth from a sample of Caucasians and Chinese populations. Dental panoramic radiographs of subjects aged 2 to 24 years belonging to United Kingdom (UK) Caucasians and Hong Kong (HK) Chinese populations were obtained from a teaching hospital. The teeth were scored and reference datasets were developed separately for males and females. Statistical significance was set at $p < 0.05$ and independent sample t-test was conducted between the average ages at assessment for each stage of development for all the teeth in both groups. The HK Chinese were dentally advanced than the UK Caucasians by an average of 5 months, however, reverse trend was observed in third molars ($p<0.05$). These findings must be considered whilst utilising population specific reference dataset for dental age estimation.

Keywords

Dental maturation; Chinese; Caucasian; Age estimation; Reference dataset; Forensic Anthropology Population Data.

1. Introduction

1.1. Background

Dental development is a process primarily regulated by genes although several other factors including nutrition, socio-economic status, environment and secular changes have been reported to influence to an extent [1,2]. Population geneticists had emphasised the need for inclusion of racial and ethnic demographics in biomedical research since they determine the expression and prevalence of various diseases [3]. Several studies have shown ethnic specific variations in physiological maturity that includes height, weight, Body Mass Index (BMI) and skeletal development [4]. A study comparing the growth patterns of Asian, Hispanic, African-American and White children from their hand-wrist radiograph found that Asian and Hispanic children mature earlier than the other two ethnic peers. Recently, a longitudinal study conducted in South Africa found that skeletal maturity was delayed by 7 months in blacks compared to white ethnicity; however no such changes were observed in girls [5]. In the context of Asia, a study that compared cervical vertebra and hand wrist development between Indonesian and Caucasian children found that white boys and girls were ahead of their Indonesian peers [6].

The above trend has been observed in dental development as studies had shown variations in both dental emergence and dental formation amongst different ethnic populations. Advancement in the emergence of permanent dentition was observed in black children compared to white although both belonged to similar socio-economic and environmental background [7]. This was supported by a study conducted in New Zealand that reported significant variations in the emergence of permanent teeth amongst Maori, Pacific Chinese, Indian and European children [8]. This observation was also evident in the primary dentition; a recent study that looked into the eruption pattern of primary dentition in American sub-ethnic population found that at a given age, native American children had more number of primary teeth compared to Black and White children [9]. A few studies have reported variations in dental formation. Dental development of Afro-Trinidadians was found to be delayed by approximately 8 months compared to UK Caucasians [10]. This finding was similar to a study on Maltese children who demonstrated earlier dental maturation than the Caucasians, although the results did not reach statistically significance [11]. An earlier study comparing the dental formation of permanent teeth of African Black and London children reported that the African blacks were advanced in maturation with mandibular third molars erupting ahead of London children [12].

1.2. Importance of Caucasians and Chinese population groups

Dental anomalies occur more commonly in specific ethnic groups since they are highly predisposed to such disorders including cleft lip and palate, supernumerary tooth, impacted canine, hyper and hypodontia [13,14]. A study conducted to evaluate arch-length discrepancies found that southern Chinese had wider dental arch width compared to Caucasians [15]. It is unclear whether this would have profound effect on dental maturation patterns. Dental emergence and dental maturation are usually seen as two different entities. Whilst dental emergence is highly variable due to the influence of local factors including crowding, pathological conditions and early exfoliation, dental maturation is merely affected by these factors. For this reason, dental maturation was considered as a reliable tool to analyse inter-ethnic variations in dental development. Understanding such variations helps in appropriate management of population specific dental conditions. This is also useful in anthropological context to conceive the degree of variation or similarity of dental development amongst ethnically distinct populations [16]. Chinese and Caucasian ethnicities are of interest to physical anthropologists and clinicians since they represent ethnically distinct populations. Understanding dental maturation in these populations would be useful in clinical dental practice in treatment planning of several dental conditions, in forensic dentistry, in appropriate use of population specific standards for age estimation as well as an indicator of public health. Hence, this study aims to analyse the maturation of permanent teeth from a sample of United Kingdom Caucasians and Hong Kong Chinese populations.

2. Materials & Methods

2.1. Study sample

This study comprised dental panoramic radiographs of subjects aged between 2 and 24 years from UK Caucasian and Chinese population groups. All the subjects were healthy without any cranio-facial disorders that might affect the dental development. The radiographs that were taken for diagnostic purpose and were re-used for this research project. For the UK Caucasian sample, radiographs were obtained from King's College Dental Institute, London, United Kingdom and for Chinese, the radiographs were retrieved from the archives of Prince Philip Dental Hospital, Hong Kong. The ethnicity of the subjects were identified by the ancestral details provided in the hospital information sheet. Ethics approval for this study was obtained from the West Cluster Board of the Institutional Review Board, University of Hong Kong (HKU-UW-120).

2.2. Development of Reference Dataset

The radiographs were scored based on the Demirjian's staging criterion that classifies tooth development into 8 distinct stages identified by the letters, A to H. The designated stages start with initial crown formation and extends until closure of root apex [17]. A stage score was assigned to each Tooth Development Stages (TDSs) for all the 16 Tooth Morphology Types on the left-side of the arch. The patients' details along with the stage scoring was then transferred to Microsoft Access® for each tooth and their corresponding stage of development. Reference data set (RDS) for Caucasian and Chinese populations were exported from the Microsoft Access® to Microsoft Excel as spreadsheets comprising of the following data for each TDS: mean Age at Attainment (AoaA), standard deviation (sd), number of teeth (n-tds) and percentile values. The above data was obtained separately for all the 16 teeth, and separately for females and males of subjects in Caucasian and Chinese populations respectively. The inter- and intra-rater agreement was assessed using Cohen's Kappa analysis [18].

2.3. Comparison of summary data between Caucasians and Chinese populations:

Using SPSS software, independent student t-test was performed between the Mean Ages at Assessment (AaA) for each TDS for all the 18 teeth. This comparison was conducted separately for males and females of Caucasian and Chinese populations. Statistical significance was set at $p < 0.05$.

3. Results

3.1. Reference datasets

This study comprised of a total of 4,835 dental panoramic radiographs of healthy subjects aged between 2 to 24 years. Amongst them, 2,529 (1,118 males and 1,411 females) subjects belong to Caucasian ethnicity who were residents in the UK and 2306 (1123 females and 1183 males) radiographs of southern Chinese subjects who were residents of Hong Kong Special Administrative Region of People's Republic of China. Distribution of samples in the Caucasian and Chinese groups was presented in Table 1.

3.2. Age at assessment

The overall difference between the average age of assessment of the tooth developmental stages between the Chinese and Caucasian RDS was -0.40 years indicating that the Chinese were dentally advanced than the Caucasians by an average of 5 months. The difference was similar in both males (-0.39 years) and females (-0.41 years). The average age of attainment of most the tooth development stages were significantly different between the

Caucasian and the Chinese, in both males and females ($p < 0.05$). Advanced dental maturation was observed in the Chinese in 77.90% of the tooth development stages compared to the Caucasians out of which 62.70% were statistically significant ($p < 0.05$), excluding third molars. Amongst the sexes, Chinese females demonstrated higher advancement (81.20%) compared to Chinese males (74.70%). A reverse trend was observed in third molars where Caucasians showed earlier dental maturation in 78.1% of TDS compared to Chinese and this was observed in both maxillary and mandibular dentition and in both sexes. Statistically significant difference was observed in 70% of the TDS ($p < 0.05$).

Looking at the third molars alone, Caucasians showed advancement of 0.96 years (0.98 years for males and 0.94 years for females). Between the sexes, third molars in Caucasian males were relatively more advanced (87.50%) than females (68.75%). The summary data of tooth developmental stages for Caucasian and Chinese was presented for males (Table 2) and females (Table 3). The average age of attainment and its dispersion for each stage of development of maxillary and mandibular left third molars in Caucasian and Chinese males and females are shown in Figures 1 and 2 respectively.

3.3. Inter and intra-rater agreement

The intra-rater agreement of the investigators who assessed the southern Chinese data (JJ) and the UK Caucasian data (GR) were 0.88 and 0.84 respectively indicating that the agreement was ‘almost perfect’. The inter-rater agreement between the investigators was 0.72 showing that the agreement was ‘substantial’ [18].

4. Discussion

Ethnic difference in children and adolescents based on skeletal development has been already established [19,20]. This is the first ever study to show comparison of dental development standards by directly pairing each of tooth developmental stages from a huge sample of Chinese and Caucasian populations. The samples utilised in the study were initially used to develop and validate reference datasets for the UK Caucasian and southern Chinese respectively [21,22]. This sort of comparison has been conducted earlier in Afro-Trinidadian and Maltese populations. It has been shown that the Afro-Trinidadians develop earlier than Caucasians by around 8 months [10]. In the current study, it was found that the Chinese develop earlier than Caucasians around 5 months in both males and females. In contrast, only a slight difference was observed between the UK Caucasians and Maltese populations and a possible explanation was that the same size between those populations were not uniform [11]. In our study, the size of samples in the Caucasian and Chinese groups were similar and hence the results drawn from this study.

The influence of genetics and the presence of population differences in dental development has been long debated [1]. Investigators have shown differences in development of dentition in similar ethnic group living in different geographical areas as well as, ethnically dissimilar groups. There was a significant delay of 0.82 years in Ethnic Australian compared to UK Caucasians, aged 4 to 24 years [23]. Similarly, significant difference in dental development was observed between Saudi Arabian and Australian Caucasian children [24]. This was refuted by Liversidge & co-workers who found no difference in dental development amongst the Caucasian and Bangladeshi residents in the UK [25]. In our study, we found significant variations in most of the tooth developmental stages in UK Caucasians and HK Chinese populations. The overall difference between the age of attainment of the tooth developmental stages in Caucasian and Chinese was -0.40 years (5 months) indicating earlier dental maturity dentition in Chinese population. In contrast, the third molar development was advanced in Caucasians compared to Chinese on average by +0.94 years (11 months). A higher difference was observed in the root development stages (Stage E to Stage H) of third molars that was gradually progressive from 15 years to 20 years and this trend was observed in both maxillary and mandibular third molars and in both sexes. This may be attributed to post pubertal growth variations in the Caucasians and its possible influence on the dental maturity of third molars [26].

The minimum age of subjects included in the HK Chinese and UK Caucasian databases were 2.69 years and 3.65 years respectively. Despite our best efforts to cover all the tooth development stages, some earlier stages of development could not be recorded, for example UL1A, UL1B and UL1C. This was due to a small number of subjects that were available for comparison in the earlier tooth development stages. This could be possibly addressed by including more number of subjects in the younger range in the UK Caucasian group as there were sufficient number of children in the HK Chinese group. However, there is a potential challenge to this as it is difficult to obtain panoramic radiographs for younger children around 2 years as the radiographs have limited diagnostic value for this age. It is to be noted that all the radiographs employed in the study were primarily taken for diagnostic purposes and were used in treatment planning of various dental conditions. Those radiographs had been re-used in the current study.

It is to be noted that the data presented in this study had been censored to exclude the outlier values thus enabling comparison between the UK Caucasian and HK Chinese tooth development stages. The data distributed beyond 3 standard deviations of the mean was considered as outlier and thus excluded. This outlier values might have arisen due to manual error in data entry process or extreme variations in dental development of individuals included in the study. The above criteria was applied to all tooth development stages except Stage H since it is unlimited in its upper border. Hence, for Stage H, the upper age limit was determined using percentile values rather than ± 3SD. The management of data for tooth development stages including third molars had been presented in our earlier paper [27]. Both UK Caucasians and HK Chinese reference datasets used in the current had been validated and the have shown to accurately estimate the age of subjects in respective populations [21,22]. The use of population specific reference dataset for dental age estimation has been emphasized in a recent study that showed accurate estimation of age of southern Chinese subjects when utilizing population specific dataset compared to non-population specific datasets [28].

Dental maturation is a sequential process and there are several staging system to capture this development. This ranges from 4 to 32 different stages [29,30]. The Anglo-Canadian classification system was employed in this study since this 8-stage method has relatively higher reliability [17]. This was reflected in “almost perfect” and “substantial” inter- and intra-examiner reliability scores respectively [18]. Using this staging system, stage to stage comparison of tooth development for all the maxillary and mandibular teeth in Caucasian and Chinese populations was conducted. This included number, mean age at assessment and its standard deviation for each tooth developmental stage. This comparison method was employed in earlier in Afro-Trinidadians and Maltese populations [10,11]. Development and validation of reference data in other identifiable human groups can shed more light on the population differences in dental development, a topic that has been still debated amongst the investigators.

5. Conclusions

This study strongly suggest the presence of variations in dental development amongst the Caucasian and Chinese population groups. Overall, the HK Chinese were dentally advanced than the UK Caucasians by an average of 5 months, however, reverse trend was observed in third molars in which UK Caucasians were advanced than HK Chinese by 11 months. These findings must be considered whilst utilising population specific reference dataset for dental age estimation.

Acknowledgements

The authors would like to thank Professor Nigel King, University of Western Australia and Dr Hai Ming Wong, University of Hong Kong for their help in the preparation of Hong Kong Chinese dental reference dataset.

References

[1] S.M. Garn, A.B. Lewis, R.S. Kerewsky, Genetic, nutritional, and maturational correlates of dental development. J. Dent. Res. 44 (1965) 228-242.

[2] J. Jayaraman, H.M. Wong, N. King, G. Roberts, Secular trends in the maturation of permanent teeth in 5 to 6 years old children. Am. J. Human Biol. 25 (2013) 329-334.

[3] E.G. Burchard, E. Ziv, N. Coyle, S.L. Gomez, H. Tang, A.J. Karter, J.L. Mountain, E.J. Pérez-Stable, D. Sheppard, N. Risch, The importance of race and ethnic background in biomedical research and clinical practice. N. Engl. J. Med. 348 (2003) 1170-1175.

[4] S.M. Garn, C.G. Rohmann, Interaction of nutrition and genetics in the timing of growth and development. Pediatr. Clin. North Am. 13 (1966) 353-379.

5. T.J. Cole, E.K. Rousham, N.L. Hawley, N. Cameron, S.A. Norris, J.M. Pettifor, Ethnic and sex differences in skeletal maturation among the Birth to Twenty cohort in South Africa. Arch. Dis. Child. 100 (2015) 138-143.

6. B.M. Soegiharto, S.J. Cunningham, D.R. Moles, Skeletal maturation in Indonesian and white children assessed with hand-wrist and cervical vertebrae methods. Am. J. Orthod. Dentofacial Orthop. 134 (2008) 217-226.

7. C.L. Lavelle, Study of tooth emergence in British blacks and whites. J. Dent. Res. 55 (1976) 1128.

8. S. Kanagaratnam, P.J. Schluter, The age of permanent tooth emergence in children of different ethnic origin in the Auckland region: a cross-sectional study. N. Z. Dent J. 108 (2012) 55-61.

9. J.J. Warren, M. Fontana, D.R. Blanchette, D.V. Dawson, D.R. Drake, S.M. Levy, J.L. Kolker, K.R. Phipps, Timing of primary tooth emergence among U.S. racial and ethnic groups. J. Public Health Dent. 76 (2016) 259-262.

10. K. Moze, G. Roberts, Dental age assessment (DAA) of Afro-Trinidadian children and adolescents. Development of a reference dataset (RDS) and comparison with Caucasians resident in London, UK. J. Forensic Legal. Med. 19 (2012) 272-279.

11. W. Elshehawi, H. Alsaffar, G. Roberts, V. Lucas, F. McDonald, S. Camilleri, Dental age assessment of Maltese children and adolescents. Development of a reference dataset and comparison with a United Kingdom Caucasian reference dataset. J. Forensic Leg. Med. 39 (2016) 27-33.

12. H.M. Liversidge, Timing of human mandibular third molar formation. Ann. Hum. Biol. 35 (2008) 294-321.

13. E.A. Mugonzibwa, R. Eskeli, M.T. Laine-Alava, A.M. Kuijpers-Jagtman, C. Katsaros, Spacing and crowding among African and Caucasian children. Orthod. Craniofac. Res. 11 (2008) 82-89.

14. M.C. Lai, N.M. King, H.M. Wong, Abnormalities of maxillary anterior teeth in Chinese children with cleft lip and palate. Cleft Palate Craniofac, J. 46 (2009) 58-64.

15. J.Y. Ling, R.W. Wong, Dental arch widths of Southern Chinese. Angle Orthod. 79 (2009) 54-63.

16. H.F. Cardoso, Y. Heuze, P. Julio, Secular change in the timing of dental root maturation in Portuguese boys and girls. Am. J. Hum. Biol. 22 (2010) 791-800.

17. A. Demirjian, H. Goldstein, J.M. Tanner, A new system of dental age assessment. Human Biol. 45 (1973) 211-227.

18. J.R. Landis, G.G. Koch, The measurement of observer agreement for categorical data. Biometrics 33 (1977) 159-174.

19. A. Zhang, J.W. Sayre, L. Vachon, B.J. Liu, H.K. Huang, Racial differences in growth patterns of children assessed on the basis of bone age. Radiol. 250 (2009) 228-235.

20. S.M. Schoenbuchner, J.M. Pettifor, S.A. Norris, L.K. Micklesfield, A. Prentice, K.A. Ward, Ethnic Differences in Peripheral Skeletal Development Among Urban South African Adolescents: A Ten-Year Longitudinal pQCT Study. J. Bone Miner. Res. 32 (2017) 2355-2366.

21. G.J. Roberts, S. Parekh, A. Petrie, V.S. Lucas, Dental age assessment (DAA): a simple method for children and emerging adults. Br. Dent. J. 204 (2008) E7.

22. J Jayaraman, H.M. Wong, N.M. King, G.J. Roberts, Development of a Reference Data Set (RDS) for dental age estimation (DAE) and testing of this with a separate Validation Set (VS) in a southern Chinese population. J. Forensic Leg. Med. 43 (2016) 26-33.

23. T.S. Peiris, G.J. Roberts, N. Prabhu, Dental age assessment: a comparison of four to 24 year-olds in the United Kingdom and an Australian population. Int. J. Paediatr. Dent. 19 (2009) 367-376.

24. A. Al-Tuwirqi, T. Holcombe, W.K. Seow, A study of dental development in a Caucasian population compared with a non-Caucasian population. Eur. Arch. Paediatr. Dent. 12 (2011) 26-30.

25. H.M. Liversidge, Similarity in dental maturation in two ethnic groups of London children. Ann. Hum. Biol. 38 (2011) 702-715.

26. M. Zandi, A. Shokri, H. Malekzadeh, P. Amini, P. Shafiey, Evaluation of third molar development and its relation to chronological age: a panoramic radiographic study. Oral Maxillofac. Surg. 19 (2015) 183-189.

27. G.J. Roberts, F. McDonald, M. Andiappan, V.S. Lucas, Dental Age Estimation (DAE): Data management for tooth development stages including the third molar. Appropriate censoring of Stage H, the final stage of tooth development. J. Forensic Legal Med. 36 (2015) 177-184.

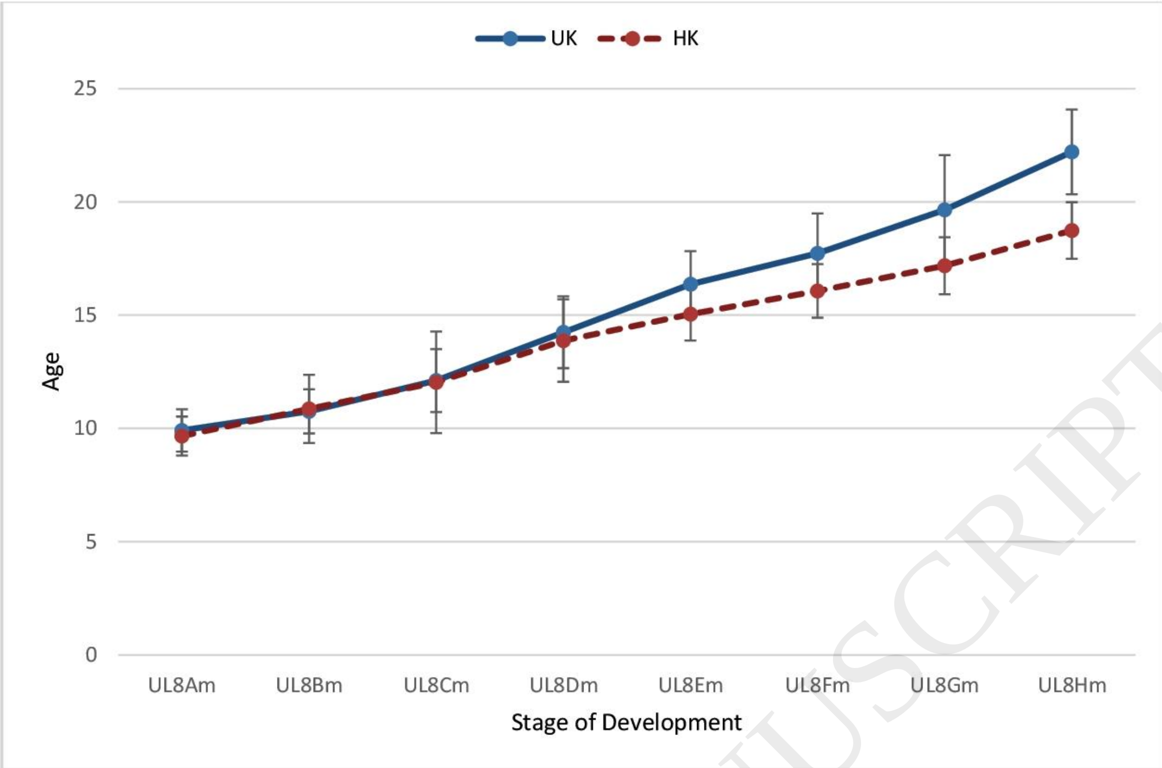
28. J. Jayaraman, G.J. Roberts, H.M. Wong, N.M. King, Dental age estimation in southern Chinese population using panoramic radiographs: validation of three population specific reference datasets. BMC Med. Imaging 18 (2018) 5.

29. K. Haavikko, Tooth formation age estimated on a few selected teeth. Proc. Finn. Dent. Soc. 70 (1974) 15-19.

30. C.F. Moorrees, E.A. Fanning, E.E. Hunt Jr, Age variation of formation stages for ten permanent teeth. J. Dent. Res. 42 (1963) 1490-1502.

Figures

Figure 1. Dental maturation of maxillary and mandibular left third molars in United Kingdom Caucasian and Hong Kong Chinese males.


UK
HK
25
20
15
10
5
0
Age
UL8Am
UL8Bm
UL8Cm
UL8Dm
UL8Em
UL8Fm
UL8Gm
UL8Hm
Stage of Development

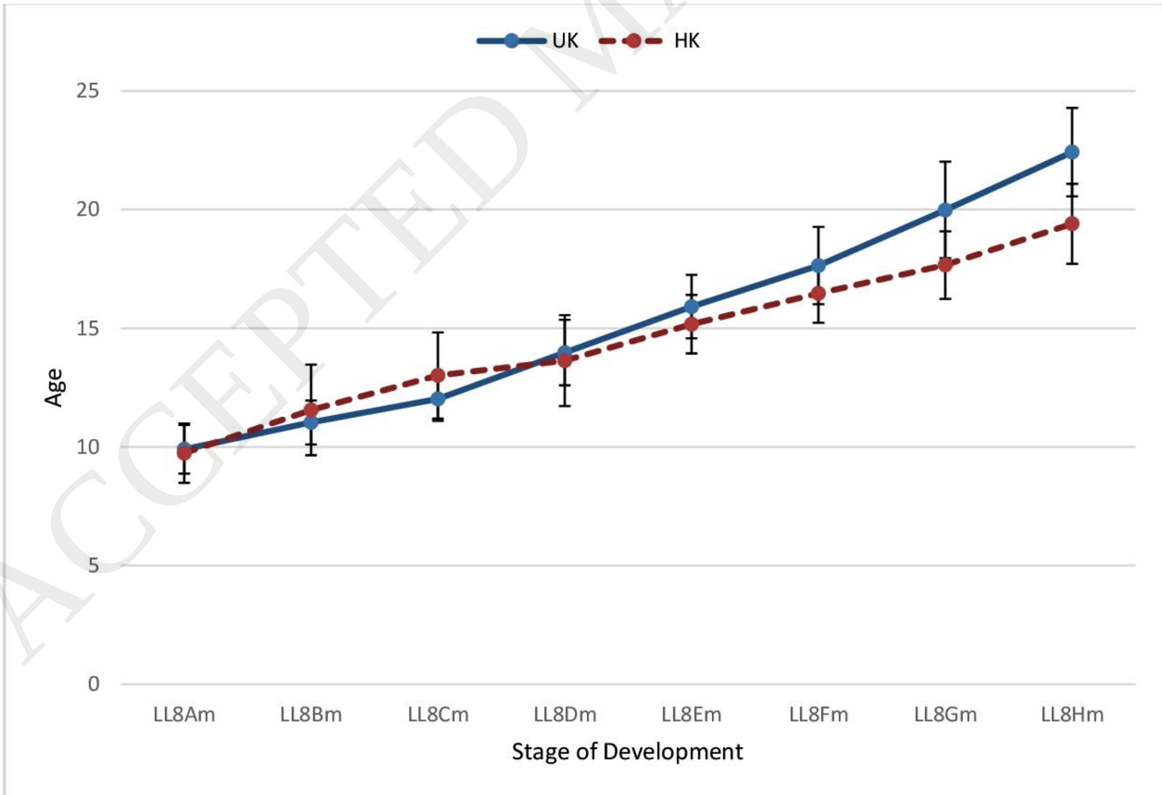
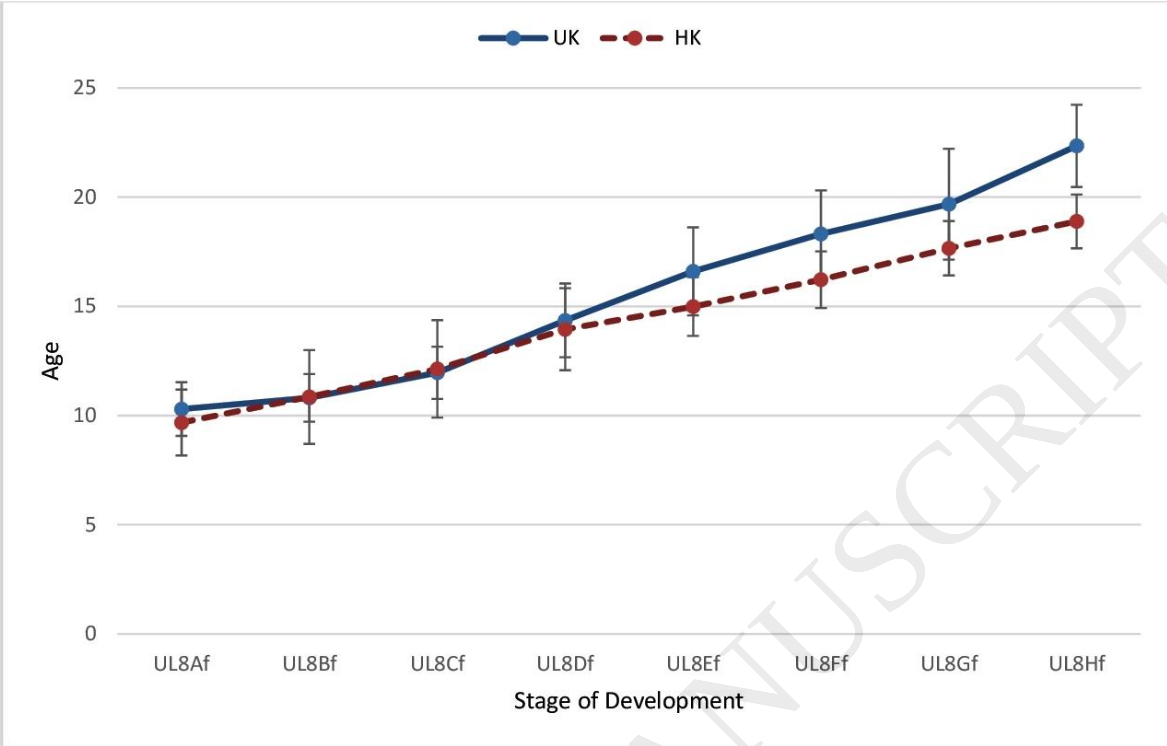
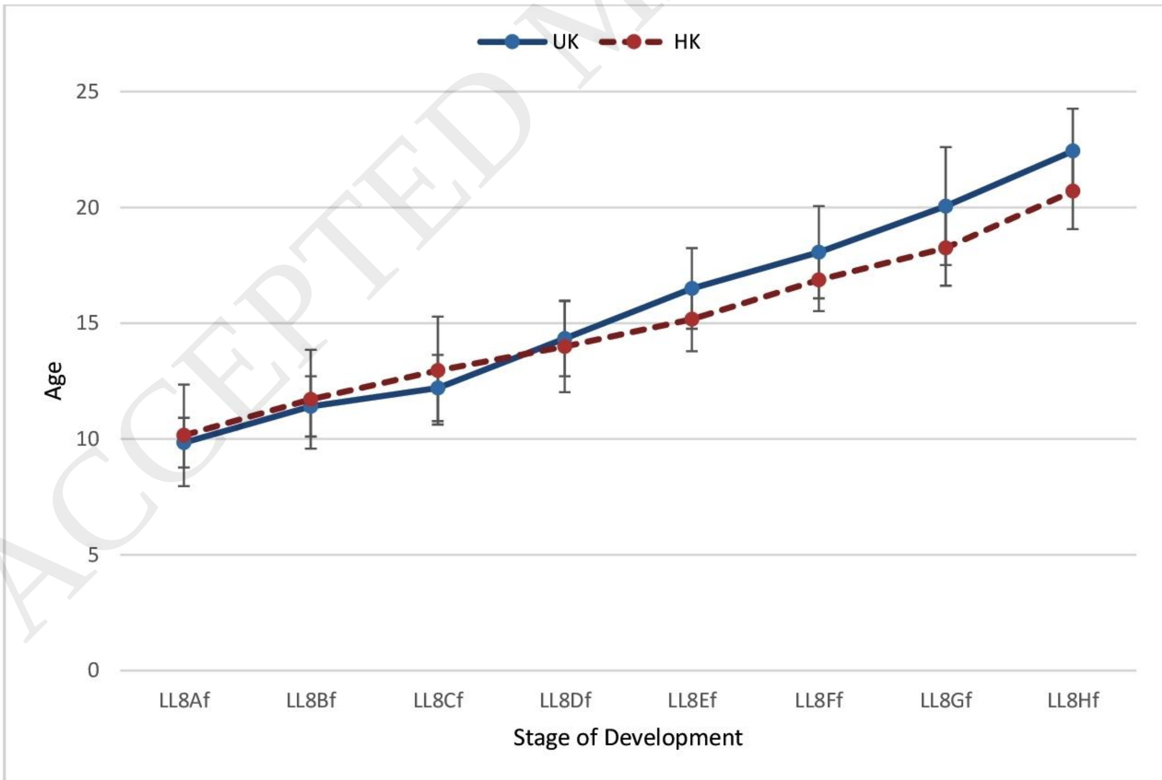

UK
HK
25
20
15
10
5
0
Age
LL8Am
LL8Bm
LL8Cm
LL8Dm
LL8Em
LL8Fm
LL8Gm
LL8Hm
Stage of Development

Figure 2. Dental maturation of maxillary and mandibular left third molars in United Kingdom Caucasian and Hong Kong Chinese females.





Legends

Tables

Table 1. Distribution of samples in the United Kingdom (UK) Caucasians and Hong Kong (HK) Chinese populations.

	UK Caucasian		HK Chinese	
Age	**Males**	**Females**	**Males**	**Females**
2.00 - 2.99 years	0	0	52	53
3.00 - 3.99 years	7	0	46	50
4.00 - 4.99 years	8	4	50	56
5.00 - 5.99 years	17	13	98	99
6.00 - 6.99 years	13	21	58	52
7.00 - 7.99 years	27	19	50	55
8.00 - 8.99 years	29	24	49	50
9.00 - 9.99 years	80	99	49	50
10.00 - 10.99 years	79	20	48	50
11.00 - 11.99 years	56	75	57	44
12.00 - 12.99 years	67	92	47	49
13.00 - 13.99 years	82	92	51	54
14.00 - 14.99 years	91	132	53	49
15.00 - 15.99 years	140	208	44	43
16.00 - 16.99 years	123	181	42	45
17.00 - 17.99 years	83	97	47	56
18.00 - 18.99 years	52	92	70	36
19.00 - 19.99 years	27	48	32	33
20.00 - 20.99 years	25	40	51	43
21.00 - 21.99 years	30	41	54	37
22.00 - 22.99 years	26	46	40	38
23.00 - 23.99 years	27	28	43	37
24.00 – 24.99 years	29	39	52	44
Total	**1118**	**1411**	**1183**	**1123**

Table 2. Summary data of tooth development stages in Hong Kong (HK) Chinese and United Kingdom (UK) Caucasians males.

TDS	HK Chinese					UK Caucasians			
	n-TDS	x-TDS	sd-TDS	Diff SC-UK	p-value^	n-TDS	x-TDS	sd-TDS	Trend
UL1Am	-	-	-	-	-	-	-	-	-
UL1Bm	-	-	-	-	-	-	-	-	-
UL1Cm	-	-	-	-	-	-	-	-	-
UL1Dm	160	4.05	1.14	-1.01	0.002*	13	5.06	0.96	<
UL1Em	88	5.74	0.67	-0.39	0.160	21	6.13	1.18	<
UL1Fm	116	7.69	1.15	-0.91	0.000*	48	8.60	1.54	<
UL1Gm	67	9.89	1.21	-1.23	0.000*	166	11.12	2.01	<
UL1Hm	94	11.10	0.90	-2.24	0.000*	336	13.33	1.92	<
UL2Am	-	-	-	-	-	-	-	-	-
UL2Bm	-	-	-	-	-	-	-	-	-
UL2Cm	44	2.97	0.51	-2.45	0.000*	13	5.43	1.70	<
UL2Dm	164	4.87	1.06	-0.82	0.010*	13	5.69	1.54	<
UL2Em	89	6.62	1.00	-0.16	0.555	18	6.77	1.11	<
UL2Fm	85	8.54	1.10	-0.15	0.495	59	8.69	1.41	<
UL2Gm	57	10.54	1.23	-0.75	0.001*	152	11.29	1.87	<
UL2Hm	188	12.64	1.36	-0.07	0.652	210	12.71	1.53	<
UL3Am	-	-	-	-	-	-	-	-	-
UL3Bm	-	-	-	-	-	-	-	-	-
UL3Cm	64	3.18	0.76	-1.70	0.000*	12	4.89	1.02	<
UL3Dm	191	5.37	1.00	-1.42	0.000*	31	6.79	1.95	<
UL3Em	90	7.78	1.02	-0.43	0.024*	78	8.21	1.35	<
UL3Fm	123	9.13	1.33	-1.17	0.000*	236	10.30	1.56	<
UL3Gm	82	12.73	1.37	0.16	0.412	107	12.57	1.33	>
UL3Hm	97	14.05	1.01	0.52	0.000*	136	13.53	0.98	>
UL4Am	-	-	-	-	-	-	-	-	-
UL4Bm	60	4.01	0.56	0.14	0.627	4	3.87	0.48	>
UL4Cm	74	5.17	0.74	-0.17	0.672	20	5.34	1.72	<
UL4Dm	162	6.85	1.22	-1.16	0.000*	67	8.00	1.31	<
UL4Em	51	8.60	0.87	-0.75	0.000*	85	9.35	1.20	<
UL4Fm	84	10.55	1.08	-0.01	0.971	49	10.56	1.24	<
UL4Gm	73	12.09	1.02	-0.48	0.009*	91	12.58	1.27	<
UL4Hm	87	13.62	0.83	0.18	0.164	125	13.45	0.94	>
UL5Am	21	4.22	0.47	0.57	0.056	3	3.65	0.31	>
UL5Bm	46	4.65	0.68	-0.07	0.826	5	4.72	0.74	<
UL5Cm	75	5.66	0.66	0.00	0.997	19	5.66	1.69	>
UL5Dm	127	7.16	1.22	-1.08	0.000*	74	8.24	1.28	<

UL5Em	103	8.60	0.96	-0.96	0.000*	162	9.56	1.39	<
UL5Fm	195	10.74	1.27	-0.43	0.028*	60	11.17	1.49	<
UL5Gm	87	12.78	1.29	0.05	0.774	94	12.73	1.26	>
UL5Hm	85	13.98	0.86	0.03	0.797	178	13.95	0.99	>
UL6Am	-	-	-	-	-	-	-	-	-
UL6Bm	-	-	-	-	-	-	-	-	-
UL6Cm	-	-	-	-	-	-	-	-	-
UL6Dm	119	3.56	0.83	-0.57	0.037*	10	4.13	0.61	<
UL6Em	79	5.32	0.68	-2.18	0.000*	31	7.51	2.29	<
UL6Fm	69	6.16	0.67	-2.92	0.000*	46	9.08	2.01	<
UL6Gm	81	7.53	1.05	-3.15	0.000*	174	10.68	2.43	<
UL6Hm	192	10.35	1.34	-2.94	0.000*	337	13.29	1.94	<
UL7Am	-	-	-	-	-	-	-	-	-
UL7Bm	50	4.86	0.73	-0.05	0.827	15	4.90	0.78	<
UL7Cm	95	5.74	0.62	-0.49	0.144	19	6.22	1.36	<
UL7Dm	164	8.11	1.32	-0.79	0.000*	128	8.91	1.36	<
UL7Em	70	10.84	1.11	0.50	0.021*	49	10.34	1.19	>
UL7Fm	39	11.62	0.88	0.19	0.387	53	11.43	1.10	>
UL7Gm	184	13.24	1.37	0.09	0.514	313	13.15	1.52	>
UL7Hm	50	13.91	0.61	-0.88	0.000*	284	14.79	1.07	<
UL8Am	28	9.91	0.94	0.25	0.303	28	9.66	0.86	>
UL8Bm	40	10.75	0.97	-0.11	0.711	38	10.86	1.51	<
UL8Cm	37	12.11	1.39	0.07	0.834	68	12.04	2.24	>
UL8Dm	132	14.25	1.59	0.37	0.053	193	13.88	1.82	>
UL8Em	35	16.37	1.46	1.32	0.000*	140	15.05	1.17	>
UL8Fm	40	17.72	1.77	1.65	0.000*	139	16.07	1.18	>
UL8Gm	150	19.65	2.42	2.47	0.000*	95	17.18	1.26	>
UL8Hm	279	22.21	1.87	3.47	0.000*	156	18.74	1.25	>
LL1Am	-	-	-	-	-	-	-	-	-
LL1Bm	-	-	-	-	-	-	-	-	-
LL1Cm	-	-	-	-	-	-	-	-	-
LL1Dm	87	3.41	0.81	-1.11	0.000*	9	4.52	0.82	<
LL1Em	93	4.93	0.84	-0.38	0.188	9	5.31	0.62	<
LL1Fm	98	6.10	0.70	0.09	0.782	16	6.01	1.21	>
LL1Gm	67	8.07	0.95	-2.64	0.000*	134	10.71	2.32	<
LL1Hm	291	11.48	1.96	-1.25	0.000*	420	12.73	2.23	<
LL2Am	-	-	-	-	-	-	-	-	-
LL2Bm	-	-	-	-	-	-	-	-	-
LL2Cm	-	-	-	-	-	-	-	-	-

LL2Dm	120	4.04	1.01	-0.69	0.015*	14	4.74	0.91	<
LL2Em	95	5.74	0.57	-0.08	0.773	17	5.83	1.15	<
LL2Fm	68	7.03	1.02	-0.61	0.053	27	7.64	1.45	<
LL2Gm	76	8.61	1.09	-2.18	0.000*	159	10.79	2.19	<
LL2Hm	63	12.49	1.74	-0.56	0.037*	378	13.05	2.01	<
LL3Am	-	-	-	-	-	-	-	-	-
LL3Bm	-	-	-	-	-	-	-	-	-
LL3Cm	69	3.15	0.69	-1.13	0.000*	6	4.28	0.80	<
LL3Dm	194	5.39	1.11	-1.27	0.006*	24	6.65	2.03	<
LL3Em	84	7.51	1.11	-0.22	0.337	64	7.73	1.57	<
LL3Fm	152	10.16	1.37	0.07	0.670	140	10.09	1.32	>
LL3Gm	78	12.63	1.26	0.15	0.426	108	12.48	1.26	>
LL3Hm	42	14.48	0.79	1.04	0.000*	145	13.44	0.99	>
LL4Am	-	-	-	-	-	-	-	-	-
LL4Bm	59	3.8437	0.59	-0.04	0.881	5	3.88	0.42	<
LL4Cm	71	4.9112	0.78	0.10	0.620	17	4.81	0.69	>
LL4Dm	149	6.3819	0.97	-1.09	0.000*	41	7.47	1.28	<
LL4Em	70	8.3692	0.96	-0.55	0.003*	86	8.91	1.25	<
LL4Fm	108	10.6292	1.21	-0.25	0.186	91	10.88	1.46	<
LL4Gm	78	12.3138	1.26	-0.08	0.696	95	12.39	1.35	<
LL4Hm	11	13.8346	0.35	0.45	0.003*	124	13.38	1.03	>
LL5Am	-	-	-	-	-	-	-	-	-
LL5Bm	59	4.56	0.68	-0.07	0.842	4	4.63	0.75	<
LL5Cm	73	5.69	0.71	0.45	0.023*	19	5.25	0.89	>
LL5Dm	124	7.00	1.19	-1.26	0.000*	55	8.26	1.71	<
LL5Em	57	8.76	1.02	-0.79	0.000*	82	9.55	1.36	<
LL5Fm	122	11.01	1.29	-0.56	0.004*	110	11.57	1.62	<
LL5Gm	70	12.70	1.27	-0.16	0.452	93	12.86	1.35	<
LL5Hm	30	14.57	0.58	0.02	0.857	230	14.54	1.08	>
LL6Am	-	-	-	-	-	-	-	-	-
LL6Bm	-	-	-	-	-	-	-	-	-
LL6Cm	-	-	-	-	-	-	-	-	-
LL6Dm	95	3.49	0.78	-1.22	0.000*	7	4.70	1.00	<
LL6Em	94	5.12	0.81	-0.01	0.990	22	5.13	0.87	<
LL6Fm	74	6.14	0.67	-1.17	0.053	18	7.31	2.36	<
LL6Gm	90	7.63	1.06	-2.52	0.000*	176	10.16	2.11	<
LL6Hm	235	10.99	1.60	-2.17	0.000*	376	13.16	1.91	<
LL7Am	-	-	-	-	-	-	-	-	-
LL7Bm	58	4.95	0.69	0.05	0.802	17	4.90	0.88	>

LL7Cm	108	6.08	0.94	-0.41	0.298	20	6.49	1.67	<
LL7Dm	134	8.03	1.27	-0.31	0.095	74	8.34	1.33	<
LL7Em	79	10.51	1.05	0.69	0.000*	84	9.82	1.07	>
LL7Fm	39	11.62	0.88	0.19	0.387	53	11.43	1.10	>
LL7Gm	98	13.31	1.29	-0.29	0.094	146	13.60	1.34	<
LL7Hm	89	14.73	0.90	-0.30	0.017*	273	15.03	1.08	<
LL8Am	52	9.90	1.03	0.16	0.539	48	9.74	1.25	>
LL8Bm	36	11.03	0.93	-0.53	0.478	35	11.56	1.91	<
LL8Cm	47	12.03	0.93	-0.98	0.009*	83	13.01	1.81	<
LL8Dm	123	13.98	1.38	0.34	0.064	164	13.64	1.92	>
LL8Em	51	15.92	1.34	0.74	0.000*	148	15.17	1.23	>
LL8Fm	51	17.64	1.63	1.17	0.000*	145	16.47	1.24	>
LL8Gm	148	19.99	2.03	2.32	0.000*	80	17.66	1.42	>
LL8Hm	147	22.42	1.87	3.02	0.000*	54	19.40	1.69	>

** British Dental Journal Classification system, TDS – tooth development stages, n-tds - number of tooth development stages, x-tds – average age of attainment of tooth development stages, sd-tds – standard deviation of tooth development stages, m – males, f – females, ^ independent sample t-test, *significance p < 0.05,* **<** *Chinese advanced than Caucasians,* **>** *Caucasians advanced than Chinese.*

Table 3. Summary data of tooth development stages in Hong Kong (HK) Chinese and United Kingdom (UK) Caucasians females.

TDS	HK Chinese					UK Caucasians			
	n-TDS	x-TDS	sd-TDS	Diff SC-UK	p-value^	n-TDS	x-TDS	sd-TDS	Trend
UL1Af	-	-	-	-	-	-	-	-	-
UL1Bf	-	-	-	-	-	-	-	-	-
UL1Cf	-	-	-	-	-	-	-	-	-
UL1Df	142	3.80	1.04	-1.26	0.000*	11	5.07	0.87	<
UL1Ef	112	5.59	0.74	-0.36	0.107	13	5.95	0.84	<
UL1Ff	107	7.54	1.05	-0.29	0.504	23	7.83	1.98	<
UL1Gf	59	9.46	1.15	-1.68	0.000*	164	11.14	2.16	<
UL1Hf	115	10.83	1.14	-1.69	0.000*	312	12.51	1.88	<
UL2Af	-	-	-	-	-	-	-	-	-
UL2Bf	-	-	-	-	-	-	-	-	-
UL2Cf	39	2.97	0.65	-1.83	0.001*	2	4.81	1.21	<
UL2Df	139	4.43	0.99	-1.17	0.000*	14	5.60	0.77	<
UL2Ef	104	6.15	0.89	-0.79	0.033*	19	6.94	1.45	<
UL2Ff	91	7.91	0.91	-0.46	0.246	33	8.38	2.19	<
UL2Gf	61	10.14	1.43	-1.17	0.000*	150	11.31	1.95	<
UL2Hf	199	12.41	1.45	-0.18	0.213*	279	12.60	1.71	<
UL3Af	-	-	-	-	-	-	-	-	-
UL3Bf	-	-	-	-	-	-	-	-	-
UL3Cf	58	2.96	0.57	-1.60	0.000*	5	4.57	0.65	<
UL3Df	163	4.87	0.96	-1.47	0.000*	16	6.34	1.32	<
UL3Ef	92	6.83	1.04	-0.82	0.001*	44	7.65	1.46	<
UL3Ff	123	9.13	1.33	-0.71	0.000*	103	9.84	1.61	<
UL3Gf	101	12.07	1.65	-0.23	0.258	141	12.30	1.49	<
UL3Hf	135	13.57	1.27	-0.31	0.016*	278	13.88	1.11	<
UL4Af	-	-	-	-	-	-	-	-	-
UL4Bf	-	-	-	-	-	-	-	-	-
UL4Cf	60	4.74	0.65	-0.84	0.089	15	5.58	1.76	<
UL4Df	172	6.52	1.14	-0.83	0.000*	42	7.36	1.35	<
UL4Ef	52	8.28	1.06	-0.93	0.000*	65	9.21	0.95	<
UL4Ff	70	10.20	1.22	0.12	0.617	50	10.08	1.32	<
UL4Gf	73	11.91	1.40	-0.80	0.000*	100	12.71	1.36	<
UL4Hf	238	13.69	1.05	-0.20	0.068	170	13.88	1.09	<
UL5Af	14	4.33	1.01	0.53	0.392	3	3.79	0.36	>
UL5Bf	52	4.66	0.51	-0.64	0.592	2	5.30	1.21	<
UL5Cf	68	5.64	0.58	-1.14	0.049*	15	6.77	2.03	<
UL5Df	116	7.03	1.12	-0.93	0.003*	43	7.96	1.83	<

UL5Ef	48	8.55	0.88	-0.74	0.000*	69	9.28	1.10	<
UL5Ff	93	10.61	1.37	-0.21	0.387	53	10.82	1.51	<
UL5Gf	80	12.58	1.51	-0.12	0.566	116	12.70	1.29	<
UL5Hf	108	13.80	1.07	-0.11	0.389	253	13.91	1.11	<
UL6Af	-	-	-	-	-	-	-	-	-
UL6Bf	-	-	-	-	-	-	-	-	-
UL6Cf	-	-	-	-	-	-	-	-	-
UL6Df	120	3.62	0.91	-1.05	0.028*	4	4.67	1.43	<
UL6Ef	61	5.17	0.60	-2.11	0.001*	18	7.28	2.32	<
UL6Ff	79	5.79	0.61	-0.63	0.023*	14	6.42	0.90	<
UL6Gf	76	7.16	0.84	-3.48	0.000*	166	10.64	2.56	<
UL6Hf	196	10.09	1.50	-2.45	0.000*	312	12.54	1.75	<
UL7Af	-	-	-	-	-	-	-	-	-
UL7Bf	51	4.98	0.75	0.58	0.072	6	4.40	0.55	>
UL7Cf	69	5.63	0.58	-0.54	0.168	12	6.17	1.25	<
UL7Df	176	7.68	1.29	-0.83	0.000*	94	8.51	1.50	<
UL7Ef	71	10.22	1.19	0.64	0.001*	64	9.58	0.97	>
UL7Ff	50	11.68	1.02	0.59	0.030*	39	11.08	1.41	>
UL7Gf	92	13.27	1.47	0.21	0.271	151	13.07	1.37	>
UL7Hf	59	13.78	0.82	-0.79	0.000*	390	14.56	1.31	<
UL8Af	22	10.29	1.23	0.62	0.148	21	9.68	1.51	>
UL8Bf	34	10.81	1.09	-0.04	0.928	30	10.85	2.15	<
UL8Cf	79	11.96	1.20	-0.18	0.433	145	12.14	2.23	<
UL8Df	149	14.36	1.69	0.41	0.032*	245	13.95	1.88	>
UL8Ef	58	16.60	2.02	1.61	0.000*	202	14.99	1.35	>
UL8Ff	47	18.31	2.00	2.09	0.000*	193	16.22	1.30	>
UL8Gf	61	19.68	2.54	2.02	0.000*	128	17.66	1.24	>
UL8Hf	117	22.35	1.88	3.45	0.000*	88	18.89	1.23	>
LL1Af	-	-	-	-	-	-	-	-	-
LL1Bf	-	-	-	-	-	-	-	-	-
LL1Cf	-	-	-	-	-	-	-	-	-
LL1Df	83	3.21	0.75	-0.87	0.053	3	4.08	0.83	<
LL1Ef	99	4.68	0.86	-0.68	0.043*	7	5.36	0.66	<
LL1Ff	102	6.08	0.77	-0.24	0.604	13	6.31	1.59	<
LL1Gf	58	7.75	0.98	-2.83	0.000*	113	10.57	2.56	<
LL1Hf	286	11.35	1.96	-0.88	0.000*	380	12.24	1.99	<
LL2Af	-	-	-	-	-	-	-	-	-
LL2Bf	-	-	-	-	-	-	-	-	-
LL2Cf	-	-	-	-	-	-	-	-	-

LL2Df	121	3.89	0.86	-1.14	0.000*	9	5.03	1.05	<
LL2Ef	93	5.60	0.51	-1.00	0.363	8	6.60	2.89	<
LL2Ff	79	6.74	0.89	-0.11	0.619	21	6.85	1.09	<
LL2Gf	69	8.42	1.02	-2.32	0.000*	140	10.74	2.31	<
LL2Hf	55	12.54	1.48	0.05	0.838	349	12.49	1.82	>
LL3Af	-	-	-	-	-	-	-	-	-
LL3Bf	-	-	-	-	-	-	-	-	-
LL3Cf	75	3.08	0.66	-1.91	0.106	4	4.99	1.68	<
LL3Df	161	5.05	1.00	-0.66	0.026*	13	5.71	1.17	<
LL3Ef	100	6.88	1.05	-0.06	0.782	31	6.94	1.35	<
LL3Ff	100	8.97	1.08	-0.73	0.001*	104	9.70	1.80	<
LL3Gf	109	11.82	1.57	-0.17	0.428	126	11.98	1.61	<
LL3Hf	41	14.32	1.09	1.09	0.000*	244	13.24	1.27	>
LL4Af	-	-	-	-	-	-	-	-	-
LL4Bf	48	3.68	0.59	-0.53	0.229	2	4.21	1.07	<
LL4Cf	66	4.51	0.65	-0.61	0.087	10	5.12	0.98	<
LL4Df	146	6.14	0.88	-0.80	0.004*	31	6.94	1.39	<
LL4Ef	71	8.14	0.86	-0.43	0.017*	56	8.57	1.09	<
LL4Ff	102	10.23	1.44	-0.11	0.625	81	10.34	1.52	<
LL4Gf	76	12.17	1.41	-0.14	0.509	112	12.31	1.47	<
LL4Hf	16	13.34	0.76	0.16	0.575	189	13.18	1.11	>
LL5Af	-	-	-	-	-	-	-	-	-
LL5Bf	62	4.67	0.67	-0.87	0.035*	3	5.54	0.96	<
LL5Cf	65	5.62	0.88	0.11	0.681	14	5.51	1.00	>
LL5Df	121	6.86	1.11	-0.84	0.000*	40	7.70	1.27	<
LL5Ef	60	8.61	0.82	-0.43	0.027*	59	9.04	1.23	<
LL5Ff	107	11.03	1.27	-0.22	0.318	87	11.24	1.65	<
LL5Gf	74	12.69	1.49	0.04	0.856	131	12.65	1.33	>
LL5Hf	33	14.78	0.80	0.04	0.815	385	14.74	1.23	>
LL6Af	-	-	-	-	-	-	-	-	-
LL6Bf	-	-	-	-	-	-	-	-	-
LL6Cf	-	-	-	-	-	-	-	-	-
LL6Df	99	3.41	0.71	-0.45	0.373	2	3.86	0.14	<
LL6Ef	73	5.09	0.68	-0.15	0.555	9	5.24	0.91	<
LL6Ff	79	5.79	0.61	-0.63	0.023*	14	6.42	0.90	<
LL6Gf	88	7.39	0.97	-2.86	0.000*	166	10.25	2.45	<
LL6Hf	245	10.82	1.77	-2.17	0.000*	397	12.99	1.83	<
LL7Af	-	-	-	-	-	-	-	-	-
LL7Bf	52	4.87	0.74	0.12	0.679	8	4.76	0.78	>

LL7Cf	85	5.84	0.75	0.04	0.855	13	5.80	0.80	>
LL7Df	147	7.67	1.23	-0.32	0.095	61	7.99	1.33	<
LL7Ef	71	10.22	1.19	0.64	0.001*	64	9.58	0.97	>
LL7Ff	53	11.66	0.95	0.20	0.347	82	11.46	1.49	>
LL7Gf	104	13.28	1.52	-0.22	0.206	181	13.50	1.34	<
LL7Hf	90	14.44	1.08	-0.64	0.000*	435	15.08	1.35	<
LL8Af	37	9.84	1.07	-0.32	0.480	21	10.16	2.19	<
LL8Bf	32	11.41	1.30	-0.31	0.147	34	11.72	2.14	<
LL8Cf	60	12.20	1.43	-0.75	0.000*	116	12.95	2.33	<
LL8Df	129	14.34	1.64	0.36	0.085	245	13.99	1.96	>
LL8Ef	60	16.50	1.74	1.34	0.000*	201	15.17	1.38	>
LL8Ff	51	18.07	1.99	1.19	0.000*	160	16.87	1.35	>
LL8Gf	102	20.06	2.54	1.80	0.000*	114	18.25	1.63	>
LL8Hf	118	22.43	1.83	1.74	0.000*	112	20.70	1.63	>

** British Dental Journal Classification system, TDS – tooth development stages, n-tds - number of tooth development stages, x-tds – average age of attainment of tooth development stages, sd-tds – standard deviation of tooth development stages, m – males, f – females, ^ independent sample t-test, *significance p < 0.05,* **<** *Chinese advanced than Caucasians,* **>** *Caucasians advanced than Chinese.*